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STRAIGHTHEAD OF RICE AND ITS CONTROL

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IN COOPERATION WITH THE LOUISIANA
AGRICULTURAL EXPERIMENT STATION

Rice heads from the same soil: *A*, Drained to control straighthead; *B*, not drained, nearly all heads being "straight."

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STRAIGHTHEAD is one of the most destructive diseases affecting the rice crop in the southern part of the United States.

All parts of the plant are affected, including the root system. The leaves are darker green and somewhat stiffer than normal. One or both glumes may be absent, and the flowers remain sterile. In severe cases, plants even may fail to head. Diseased plants remain green after normal plants are mature and dead. An abundance of large or water roots and few small roots and root hairs develop.

The presence of organic matter in certain stages of decay produces a condition of soil that allows more water to be taken in, and this tends to press out the air to such an extent that the root system fails to develop normally, thus disturbing the nutrition of the plant, which produces straighthead.

To prevent or control straighthead, irrigate about 10 days after the plants emerge. If symptoms of the disease are seen, drain the land six weeks after irrigation and leave dry from two to three weeks. When the plants begin to turn yellow and show signs of withering, apply water and retain it for the remainder of the season.

Contribution from the Bureau of Plant Industry

WM. A. TAYLOR, Chief

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STRAIGHTHEAD OF RICE AND ITS CONTROL.

CONTENTS.

	Page.		Page.
Occurrence and damage	3	Cause of straighthead	10
Description of straighthead	4	Control measures	11
Symptoms shown by parts above ground	4	Summary of investigations	11
Symptoms shown by the root system	6	Recommendations	16
Other forms of sterility in rice	8		

STRAIGHTHEAD is one of the most destructive diseases of irrigated rice in the southern part of the United States. Rice heads (panicles) which are so nearly sterile that they remain erect when mature rather than droop normally are commonly referred to as "straightheads." According to this definition, plants rendered sterile through any cause may be termed straighthead plants; in fact, a number of types of sterility will be mentioned in this bulletin in comparison with the most common or typical form of straighthead, with which it deals principally.

The Office of Cereal Investigations of the Bureau of Plant Industry, cooperating with the Louisiana Agricultural Experiment Station, began an investigation of this and other diseases of rice at the Rice Experiment Station, Crowley, La., in the spring of 1919. Considerable information had been obtained previously by the agronomists at the station, but straighthead was at that time considered a very puzzling problem. There apparently was sufficient evidence to prove erroneous each of the many theories advanced as to the cause of the trouble. Collier (Ill. Agr. Exp. Sta. Cir. 156) did considerable valuable work on the disease in Arkansas in 1910 and 1911, but apparently the investigations were not carried far enough to show the importance of certain factors. On this account the control measures suggested by him were not adopted. It is the purpose of this bulletin to give a clear description of the disease as it occurs in the field and to present the best evidence obtained as to its cause and means of prevention.

OCCURRENCE AND DAMAGE.

Straighthead in all probability has been damaging the rice crop of the Southern States ever since the present methods of irrigation were adopted. Collier in 1912 estimated the annual loss at 20 per cent of the crop, and at 12 to 15 per cent on 8,000 acres of rice in

Arkansas in 1910 and 1911. The disease is especially destructive in Louisiana, Texas, and Arkansas, which comprise the important rice-growing section of the South. Within this section the damage generally is localized, owing to the fact that the disease is more prevalent on land on which nonirrigated crops have been grown for a number of years and on virgin soil than on land previously sown to rice. In 1919 and 1920 more damage was caused in the rice fields in the Mississippi Valley section of Louisiana than in previous years, because more land on which nonirrigated crops had been grown was sown to rice.

Straighthead plants were found by the senior writer in two selections of Japanese rice at the rice field station at Biggs, Calif., on September 29, 1919. Both selections were in the nursery, where only a rod row of each was sown, in both of which about 50 per cent of the plants showed symptoms of straighthead.

In a personal interview with the writers at Crowley, La., in 1920, Dr. José J. Mirasol, of the Philippine College of Agriculture, described the disease as occurring in the Philippine Islands. He stated that it causes considerable damage to rice on land where mung beans have been grown the previous year. We have no other reports of the occurrence of straighthead in the rice-growing countries of the Orient.

DESCRIPTION OF STRAIGHTHEAD.

The disease affects all parts of the plant both above and below ground, but the symptoms are not easily detected until the plants have headed. There are early symptoms, however, which aid in detecting the trouble in time to aerate the soil and check the further development of the disease.

SYMPTOMS SHOWN BY PARTS ABOVE GROUND.

Straighthead plants are very hard to detect before they start heading. A thorough knowledge of the rice plant, the soil and watering, and a familiarity with the different stages of the development of straighthead are necessary if one is to detect the disease with any degree of certainty before the heads emerge. The leaves of diseased plants appear darker green than the leaves of normal plants. They also tend to stand more erect and present a stiffer appearance in general than is characteristic of normal leaves. The sheaths are affected in a similar way. They adhere closely to the stem and are hard to remove even after the plants are dry (see title-page illustration). The heads emerge slowly and do not extend as far above the top sheath as do normal heads (see fig. 5). Plants affected severely may even fail to head. As soon as the glumes (chaff or hulls) start to develop, symptoms of the disease can be seen if the head is removed from the boot and examined carefully. At this stage aborted glumes are the most noticeable symptom (fig. 1, *B* and *C*). The entire flower

FIG. 1.—Branches of rice heads, showing (*A*) normal rice kernels and (*B* and *C*) sterile flowers with abnormal glumes from straighthead plants. Note the absence of one glume in some of the flowers. (Much enlarged.)

may be absent in some cases. In others, only one glume is absent and the other is distorted, curving inward, somewhat in the shape of a sickle (fig. 1, *B* and *C*). Some flowers apparently may be complete, but still remain sterile. Most of the flowers on diseased plants never open, and no indication of seed development can be seen, while others open normally but fail to produce kernels. All gradations may be found from nearly normal heads with only a few aborted sterile flowers to completely sterile heads with distorted glumes. The distorted glumes generally are more noticeable on the long-grain varieties. The short-grain rices, as a rule, are more resistant to the disease. Straighthead plants remain green, and the heads especially are noticeably green, after normal plants of the same age are mature, thus

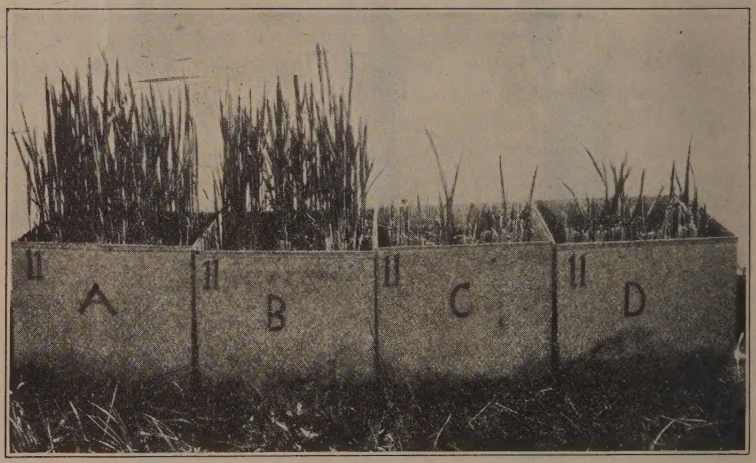

FIG. 2.—Second growth developing from rice plants after harvest. *A* and *B*, Vigorous growth from the lower nodes and the crown of straighthead rice plants; *C* and *D*, a few weak suckers developing from the lower nodes and the crown of normal plants.

making possible the detection of diseased plants in the field at harvest time. With their failure to produce seed, the straighthead plants develop numerous suckers from the lower nodes and crown in a final effort at reproduction (fig. 2, *A* and *B*).

SYMPTOMS SHOWN BY THE ROOT SYSTEM.

Plants affected with straighthead show strikingly abnormal root systems (figs. 3 and 4). If the plants are carefully dug up with a large mass of soil and washed by shaking slowly in water, so as not to break the tender roots, the straighthead plants will be found to have a large number of coarse or water roots (fig. 3, *B*) and these only sparingly branched, while the normal plants will have fewer of these coarse roots but will be branched abundantly and will produce a large

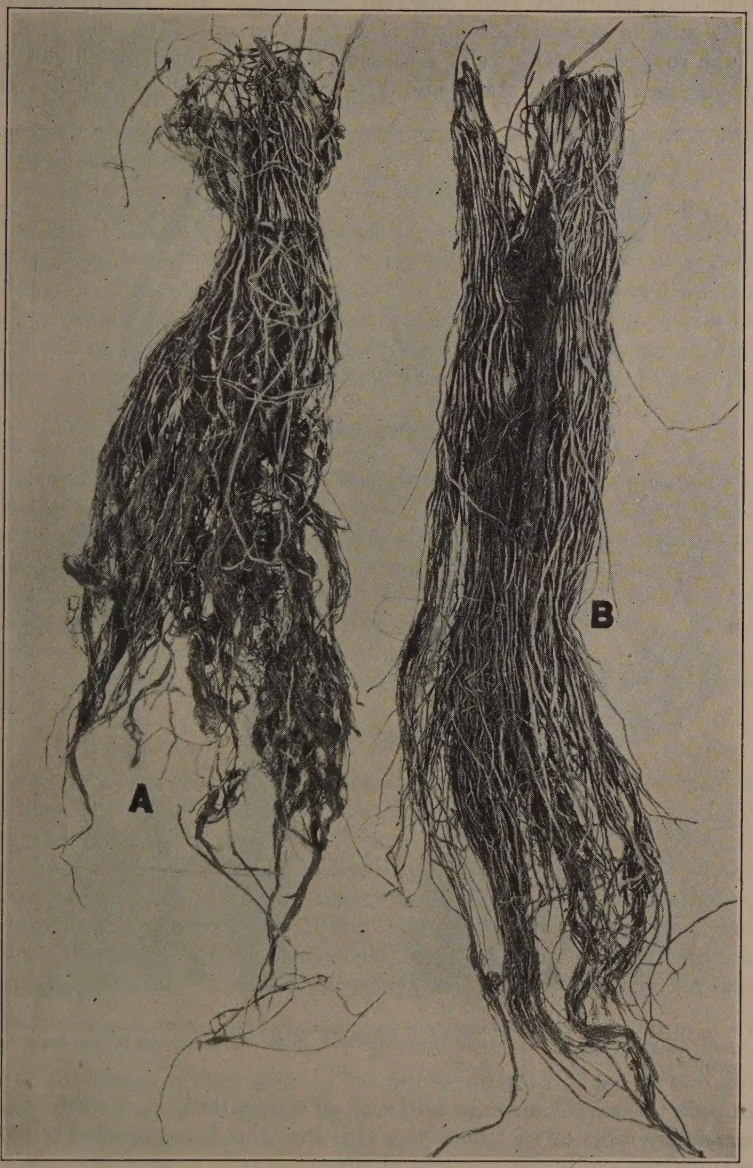

FIG. 3.—Root system of a normal rice plant (*A*) with comparatively few large roots, all of which have numerous branches with fine root hairs; and a straighthead plant (*B*), showing numerous large roots with very few branches and root hairs.

number of secondary roots and root hairs (fig. 3, *A*). The absence of these smaller roots on diseased plants is very noticeable (fig. 4, *B*). These root characteristics of diseased plants are useful in detecting the disease in its early stages and thus making it possible to air the soil

FIG. 4.—Rice roots (much enlarged) showing (*A*) three large roots from a normal plant, with numerous small roots and root hairs; and (*B*) three large roots from a straighthead plant, with but few small roots and root hairs.

in time to prevent a severe outbreak of straighthead. A scarcity of secondary roots or root hairs is a sign that the disease probably will occur if the soil is not properly aired.

OTHER FORMS OF STERILITY IN RICE.

A number of other forms of sterility may be confused with the disease properly called straighthead.

ALKALI INJURY.

In some parts of the rice-growing section of California, alkali is so abundant in spots as to weaken the plants, causing them to become stunted and of a rusty appearance. Some of them fail to produce seed after heading, but these do not remain green as do plants with typical straighthead.

DROUGHT INJURY.

In the driest parts of the rice section of California the soil dries so thoroughly when the irrigation water is exhausted that the growth of rice plants is checked immediately. If the water supply gives out when the plants are heading they will remain sterile and the heads will fail to droop. The rapid dying and the blasted appearance of these plants distinguish this trouble from the straighthead disease.

NITER SPOTS.

Near Woodland, Calif., in 1919, some areas of green plants were seen in fields of rice at harvest time. These green plants were found to be sterile and "straight," but none of the typical flower symptoms were present. These areas were known locally as niter spots. Nitrogen applied to rice in Louisiana in sufficient quantities to kill most of the plants failed to produce sterility in the ones that headed. There may be other chemical elements present in these spots in California, or the cause may be closely related to that inducing straighthead in the South.

DRY, HOT WINDS.

Dry, hot winds are said to cause considerable sterility of rice in California. This condition is more noticeable on levees and on land where there is a lack of water. The heads have a blasted appearance, as though they had been scorched by fire. Dry, hot winds at the time the heads are emerging apparently are responsible for the injury. A stiff 2-day wind followed by a sudden drop of temperature produced the same effect on rice that had just headed in Louisiana in September, 1920. This was especially noticeable where the soil had dried.

POOR GRASSY LAND.

In the rice-growing region of the South, sterile rice plants may be noticed on very poor grassy land. This condition is more common near levees where there is not sufficient water to kill the weeds and grass. The glumes of these sterile heads are likely to be stained by invading fungi. None of the typical straighthead symptoms is present except the sterile erect heads. This form of injury is not common.

ROTTEN-NECK (PIRICULARIA).

Rotten-neck, a fungous disease, may kill rice heads sufficiently early to prevent their filling normally. The frequent breaking over of the heads and the brown discoloration caused by the fungus prevent their being mistaken for straighthead.

CAUSE OF STRAIGHTHEAD.

Investigations have shown that straighthead is caused by certain unfavorable soil conditions. The disease has been produced experimentally and has been prevented by regulating the irrigation water in a manner described later. All attempts to find a parasitic organism causing straighthead have failed.

The disease is most prevalent on virgin soil and especially on land on which nonirrigated crops have been grown for a number of years preceding the rice crop. The reverse would be expected if the disease were caused by a parasitic fungus. The soils mentioned above apparently contain certain types of organic matter which under certain methods of culture and irrigation render the condition of the soil unfavorable for growing rice. Chemical and biological factors may aid primarily in producing this condition. More straighthead seems to develop when rice follows corn and cowpeas than when it follows other cultivated crops. This result possibly may be due to the fact that these crops are not given as clean cultivation as are other nonirrigated crops used in rotation with rice. The type of organic matter furnished by the crops may also have some influence. The quantity of organic matter under certain conditions apparently has little to do with the development of straighthead. In some experiments large quantities of organic material were added to the soil for the purpose of producing the disease, but the result was an increased yield of rice.

The soil must necessarily become adjusted to irrigation. Certain types of organic matter while decaying apparently furnish elements which injure the condition of the soil for growing rice. The disease is more prevalent after wet winters, which tend to check the decay of organic matter. Straighthead often occurs in distinct rows where rice follows corn or corn and cowpeas. In the rice section of the South, corn is grown on ridges. When this land is broken for rice the corn and pea plants are thrown to the middle furrow between the corn rows. Straighthead has been seen to follow the middles, while the plants over the old corn rows were normal, thus indicating that organic matter aids in producing the disease.

The disease occurs on soil which seems to be somewhat loose and which forms a soft yielding mud when irrigated. This loose condition no doubt is caused by decaying organic matter under certain

peculiar conditions. Where the soil becomes soft, air is pressed out by the water. Where the air is pressed out from the soil in this fashion the plants produce an abundance of the adventitious type of roots, or water roots, and very few secondary roots and root hairs. In this case the plant is dependent more or less on the mineral elements in the free soil water for food. In the absence of the feeding roots, or root hairs, which normally attach themselves to the soil particles and absorb the desirable food elements, the nutrition of the plants is disturbed and no rice kernels are produced. Hence, the plants remain sterile, and straighthead is the result.

CONTROL MEASURES.

SUMMARY OF INVESTIGATIONS.

Straighthead can be prevented by the proper aeration of soils which are in such condition as to cause it to develop. Collier (Ill. Agr. Exp. Sta. Cir. 156, 1912) gave some very striking results of work done in Arkansas in 1910–11. His investigations were not continued long enough to discover the early symptoms of the disease which, when recognized, enable the farmer to take measures for its prevention. He recommended aerating at the time the head is forming in the boot. It is now known to be too late to begin aeration when the head is developing. The period of aeration should be completed by this time and the water again turned on, in order that the plant may reach its maximum vigor before flowering. Collier's experimental records show, however, that he actually aerated his plats earlier than he recommended in his conclusions, and the result was that he obtained yields as high as 65 to 74 bushels per acre on aerated fields, as compared with 15 bushels on plats not aerated.

Experimental results obtained at the Rice Experiment Station, Crowley, La., prove conclusively that if aeration is properly carried out it will prevent straighthead. In experiments conducted by the station in 1911, near Washington, La., parts of the plats were so high that irrigation water could not be held on them. There was an easily noticeable difference in the amount of straighthead where the water was held continuously and where it was kept on the land only a part of the time or not at all. Where the water could not be held, yields as high as 59.5 bushels were obtained, while the yield on adjoining plats where water was held continuously at a considerable depth was only 20 bushels per acre. In 1915 there was a very noticeable difference in the percentage of straighthead in plats that were irrigated at different times for the purpose of testing the effects of time of irrigation on yield. Plats that were irrigated 10, 20, and 30 days after the plants emerged had rather high percentages of straighthead, while plats irrigated 40 to 60 days after emergence

were almost, if not entirely, free from the disease. These plants had a chance to develop a good root system before the water was applied. Sixty days, however, proved to be too long to hold off the water, for the plants became considerably weakened. The yield was better where the water was held off 40 days than where it was held off 60 days, but where applied earlier than 40 days the yield was greatly reduced.

Further attempts at confirming these results were not successful until the summer of 1920, when a series of experiments was arranged in which various types of soil, a number of chemicals alone and in combination, and different methods of irrigation were employed. Soil taken from land on which rice was grown the year before and soil taken from land on which soy beans were grown the year before and rice before that failed to produce the disease under any form of treatment. But soil taken from an oat field where corn, cowpeas, soy beans, and oats had been grown previously, but on which no rice had been grown, produced straighthead in abundance where the soil was not properly aerated. This soil was rather loose and in poor condition for growing rice with the method of continuous irrigation commonly practiced.

The chemicals used were acetic acid, sodium hydroxid, ammonium sulphate, nitrate of soda, acid phosphate, potassium sulphate, and ground limestone. These substances were added singly and in various combinations and in different quantities, but seemed to have no influence on the production of straighthead. Acid and alkali were added in sufficient quantities to cause the irrigation water to color litmus paper. The plants apparently were weakened, but no straighthead developed. The nitrogenous fertilizers were applied in quantities sufficient to kill some of the plants, but those that lived produced good rice. Organic matter in the form of stable manure and green manure failed to produce the disease when applied in abundance. Straighthead was produced only on the soil that was in such condition that the air largely was excluded and replaced by water when irrigated. As mentioned above, the land where this soil was obtained had grown nonirrigated crops for a number of years, but no rice. It contained considerable organic matter which was in an advanced state of decay.

In order that these experiments might be carried out under similar environmental conditions and as close together as possible, the various types of soil were placed in galvanized cans 16 inches square and 15 inches deep, with a small pipe at the bottom to regulate the water. About 9 inches of soil were placed in each can and the cans were arranged so as to prevent as much as possible the direct rays of the sun from striking the sides. Enough space was left between to provide ventilation and prevent overheating; in fact, the tempera-

ture of the irrigation water in the cans ran very close to that in the field. Fifty plants grew to maturity normally in a can (figs. 5 and 6). By using these cans it was possible to conduct many more experiments and to regulate conditions more closely than was possible in the field. Ten cans were used in each experiment. Although the results obtained have already been mentioned briefly, the following is a more detailed account of the effects of aerating the soil on which straighthead appeared.

FIG. 5.—Rice grown on soil the first year after nonirrigated crops: *A* and *B*, Not drained; 97 per cent straighthead developed. *C* and *D*, Drained; no straighthead developed.

Honduras rice was sown at different times, and various methods of aeration were employed. Seed from California gave the same results as seed grown in Louisiana. Plants grown in soil which was not irrigated were small and yielded poorly, though they were free from straighthead, while those grown in soil which was kept saturated with water produced a fair yield with no straighthead. This was true also of plants where the water was held 1 inch deep or less, but where the water was held from 2 to 5 inches deep continuously an average of 94 per cent of straighthead occurred. In the above experiments the water was applied 25 days after seeding.

In a second series of experiments irrigation water was applied 18 days after planting and drained off 33 days later; then applied again after 21 days. These gave the most satisfactory results. The plants produced heavy well-filled heads with no indications of straighthead. An average of 97 per cent of straighthead plants resulted in the same series where the water was held continuously at a depth of 4 to 5 inches (see figs. 5 and 6).

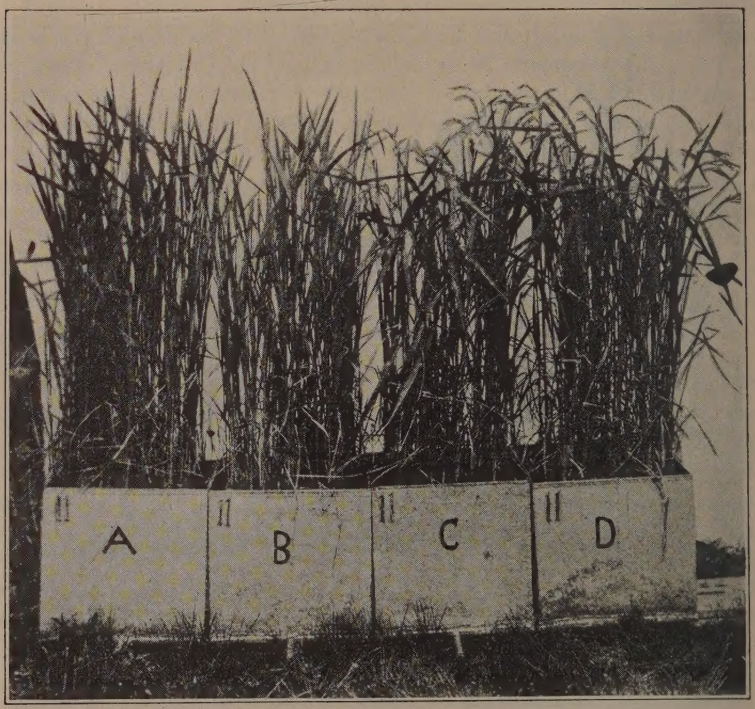

FIG. 6.—Rice grown on soil the first year after nonirrigated crops: *A* and *B*, Not drained; 100 per cent straighthead developed. *C* and *D*, Drained; no straighthead developed.

In a series of experiments where the water was not applied until the forty-first day after seeding, a heavy yield of rice was produced, even though 9½ per cent of straighthead resulted. This method is not a sure preventive, however, as adjoining cans which were sprinkled occasionally to keep the soil wet through the 40-day period produced 70.5 per cent of straighthead after irrigating. Such a condition might be expected in a wet season. Plants irrigated on the sixtieth day were free from the disease, while 84.5 per cent of straighthead occurred in adjoining cans irrigated 18 days after sowing. Plants in the same series, where the soil was aerated during the

time the panicles were forming in the boot, were weakened considerably, and the panicles, although not "straight," were very small and light.

When about 7 weeks old the rice plants were removed from a series of cans containing soil of the type used in the above experiments and the cans were resown, but no straighthead developed under any method of irrigation. The extra cultivation at the time of the first seeding and the growth of the resulting plants seemed to correct the poor condition of the soil. On the other hand, soil left unsown up to the end of the 7-week period and then sown produced plants which were 84 per cent "straight" where the soil was not aerated.

Cans that were irrigated 41 days after seeding and the surface of the water covered with a film of heavy petroleum oil to exclude air produced plants which were 100 per cent "straight." This film of oil doubtless served to hold in certain gases formed in the soil, as well as to prevent air from entering the soil.

In these experiments, the water was applied later than is the common practice; for weeds appear early in the field and are likely to injure the rice unless controlled by early irrigation. The general practice is to irrigate about 10 days after the plants emerge, or when they are about 6 to 8 inches tall. For this reason it would not be advisable to hold the water off for 40 days or more in order to prevent straighthead. As previously stated, 40 days would not be sufficient in all cases to prevent the disease, and 60 days is very likely to reduce the yield, even though weeds are not considered. The best time to apply the water is when the plants are about 8 inches tall, as this will check the weeds. Allow this water to dry off gradually, and if the soil is not free from water within 5 to 6 weeks after irrigation, drain it off and allow the land to remain dry for 2 to 3 weeks. If the soil becomes dry enough to crack and the plants turn yellow and start to wither, the results will be better. After the water is returned it should be kept on until the end of the season.

Even though the plants do not appear diseased, good yields will be obtained, and no water should be wasted where the land is aerated. In dry seasons, when the water is allowed to dry gradually before draining and the land is kept dry for three weeks, there should be a saving of water. Collier obtained yields as high as 65 to 74 bushels per acre on aerated plats, while adjoining plats yielded only 15 bushels on account of straighthead in the absence of aeration. Experiments conducted at the Rice Experiment Station, Crowley, La., by the junior writer show that the 3-year average acre yield (1917 to 1919, inclusive) was just as high when the plats were aerated by draining six weeks after the water was first applied as when the water was held

on the land continuously. These experiments were on good soil, and the plats were practically free from straighthead. The average yields for the three years were somewhat lower on plats where the water was retained either four or eight weeks before draining and aerating.

The results of these experiments show conclusively that irrigating for six weeks and then draining to aerate, which is the method recommended to control straighthead, does not reduce yields even where no disease occurs and the land is in good condition. The treatment necessary to insure control of the disease, therefore, can be applied safely even if no disease has begun to appear.

RECOMMENDATIONS.

(1) Prepare the land thoroughly before seeding.

(2) Irrigate to a depth of about 4 inches about 10 days after the plants emerge, or when they are about 6 to 8 inches tall. The water will check weeds and give the plants a better start.

(3) If land previously sown to nonirrigated crops or if virgin soil is sown to rice, watch for symptoms of the disease.

(4) Straighthead seldom occurs after the first year where rice follows rice. If it occurs in the second or third year, it is not likely to be destructive.

(5) If indications of the disease are seen, carefully dig up a few of the plants and also a few from soil where rice was grown the previous year and yielded well, wash the roots carefully, and compa If there is a scarcity of small roots and root hairs on the suspected plants the soil should be drained.

(6) If aeration is desired, drain five to six weeks after water is applied.

(7) Allow the soil to dry thoroughly, even to the extent of surface cracking. The yellowing and withering of plants is really desirable and not harmful if not carried too far. The desired results should be obtained in two or three weeks, provided the season is not too rainy, in which case the soil will dry more slowly.

(8) After the soil is dried and aerated, apply the water to an a age depth of 4 to 5 inches and retain it throughout the remainder t he growing season.

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